Incorporating Wetlands in Water Quality Trading Programs: Economic and Ecological Considerations

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Wetlands and the Evaluation of Ecosystem Services in a Watershed Context

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1) Conditions under which trading makes sense
2) Graphical representation of trading
3) Issues in Economics
4) Economic research directions

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Economically, Trading Makes Sense When there Exists…

- Cost heterogeneity
- Increasing marginal costs of abatement
- Regulatory driver
  - Real or Anticipated
- Infrastructure
  - Bank, Clearinghouse, Securitization
- Relative certainty

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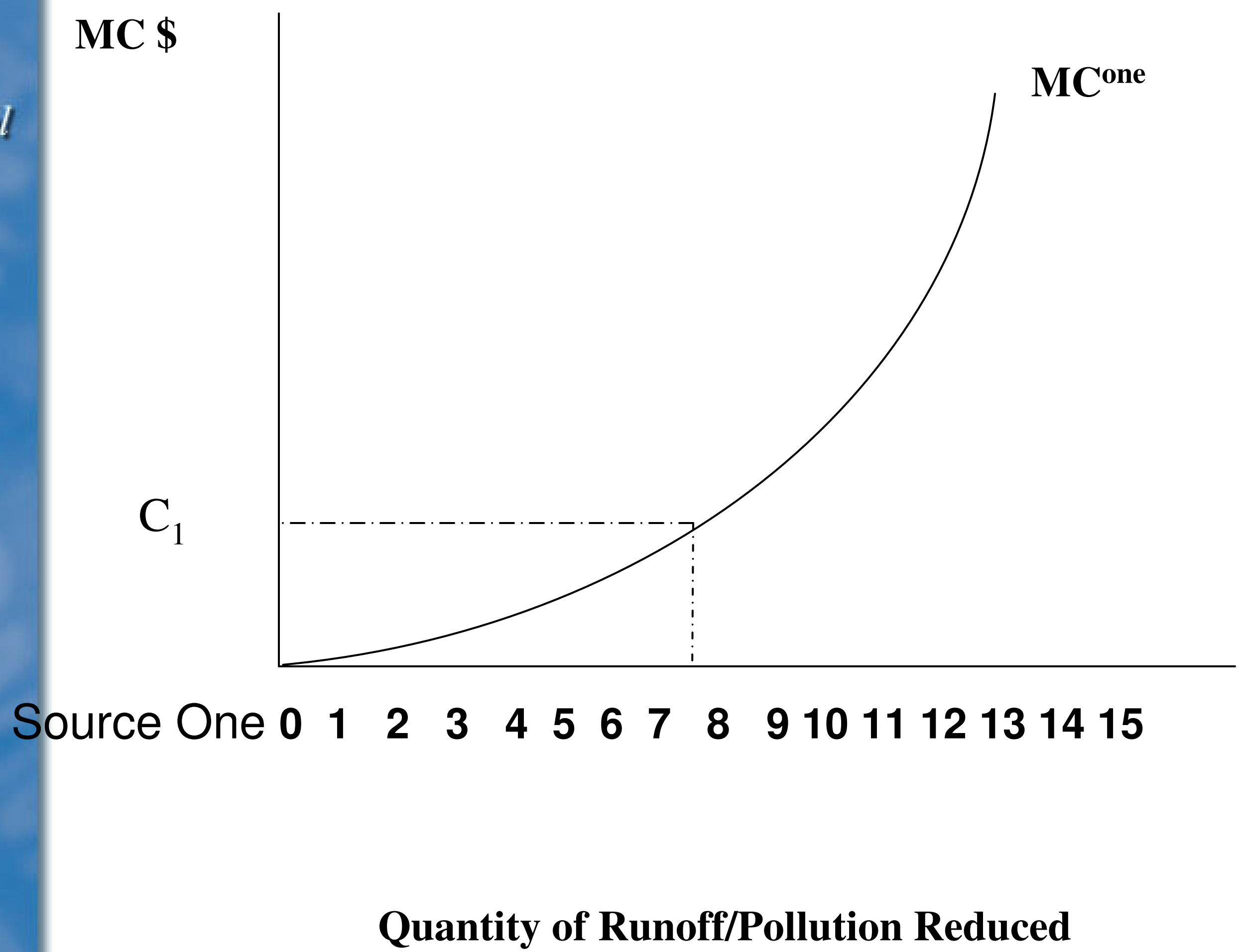

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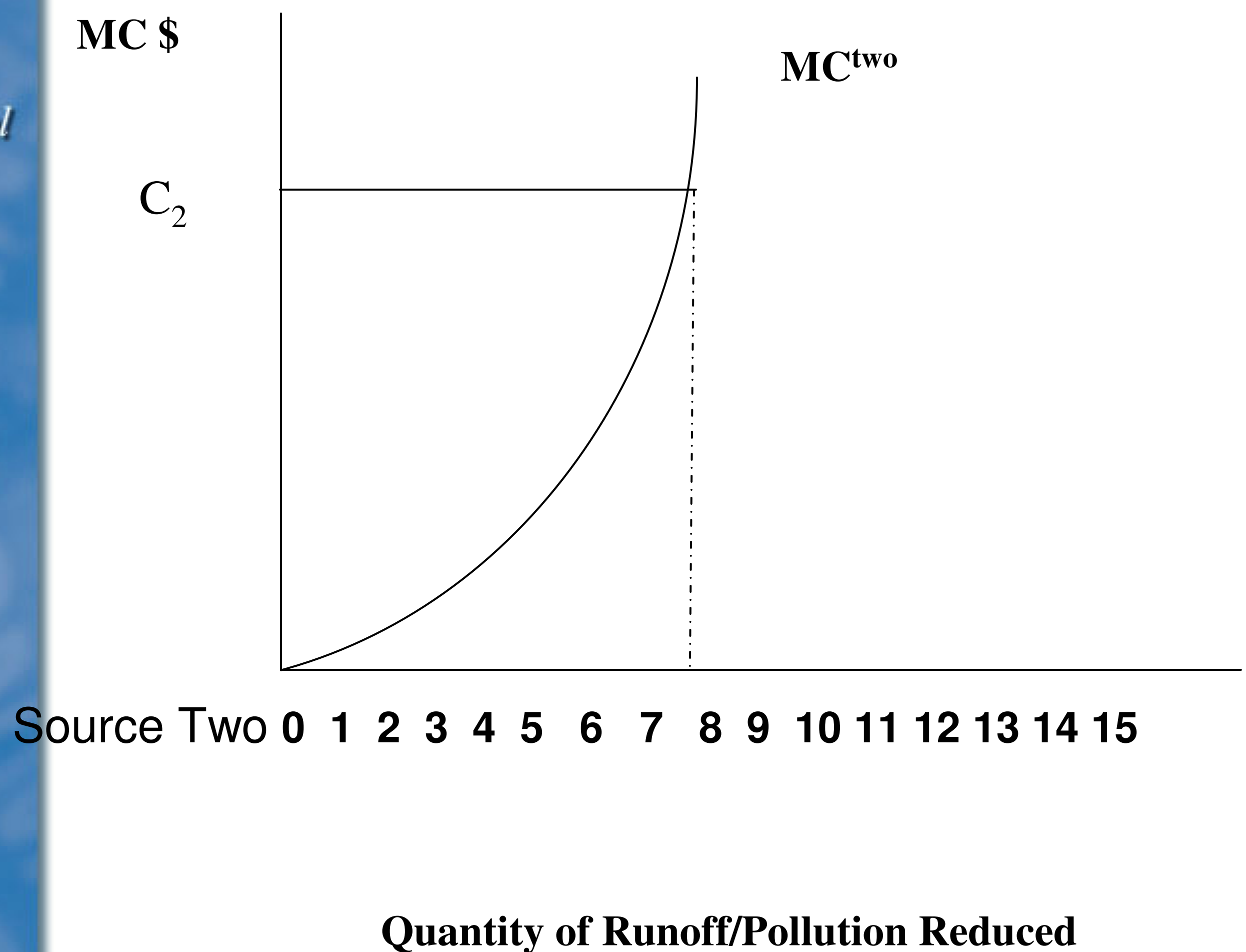

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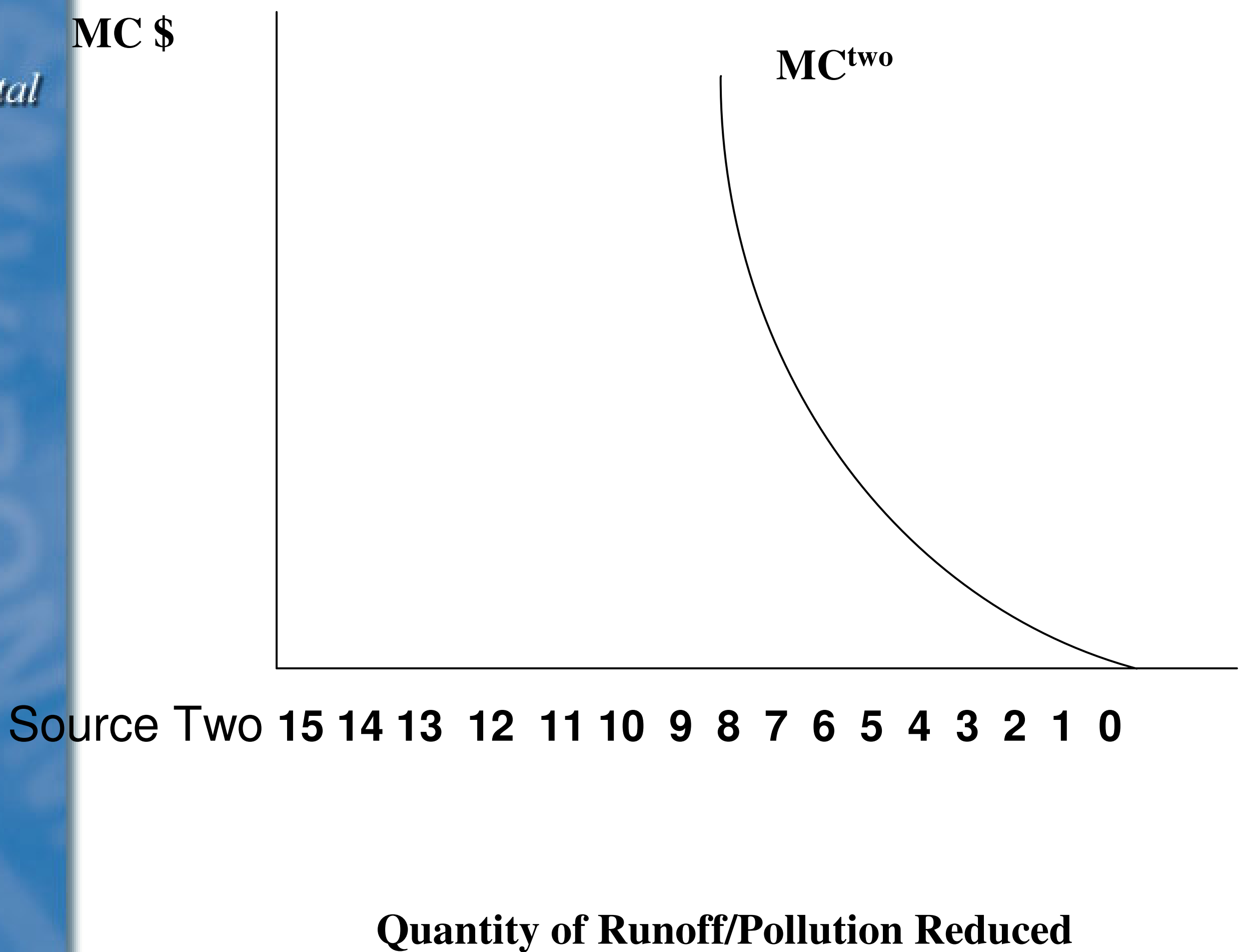

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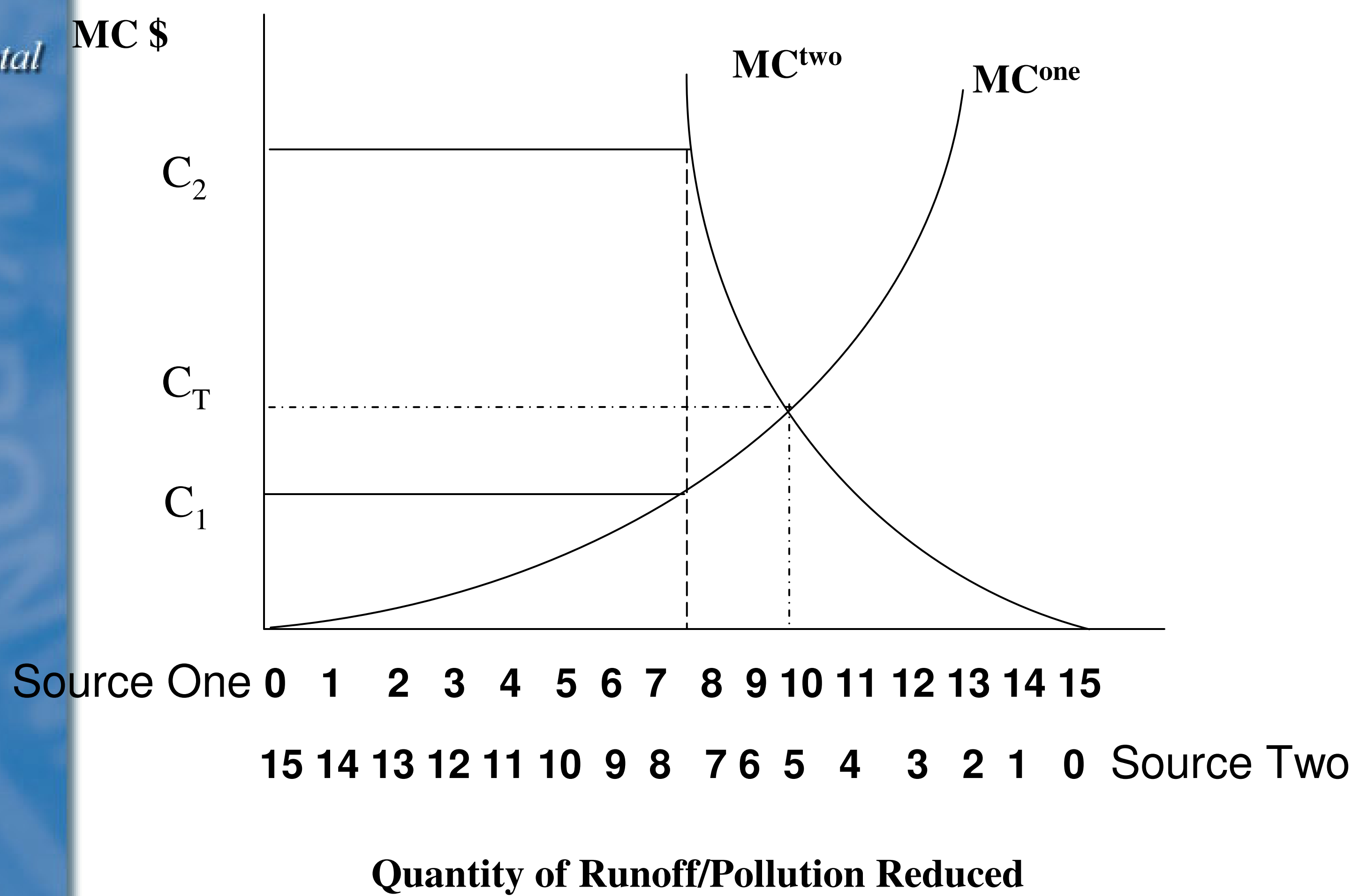

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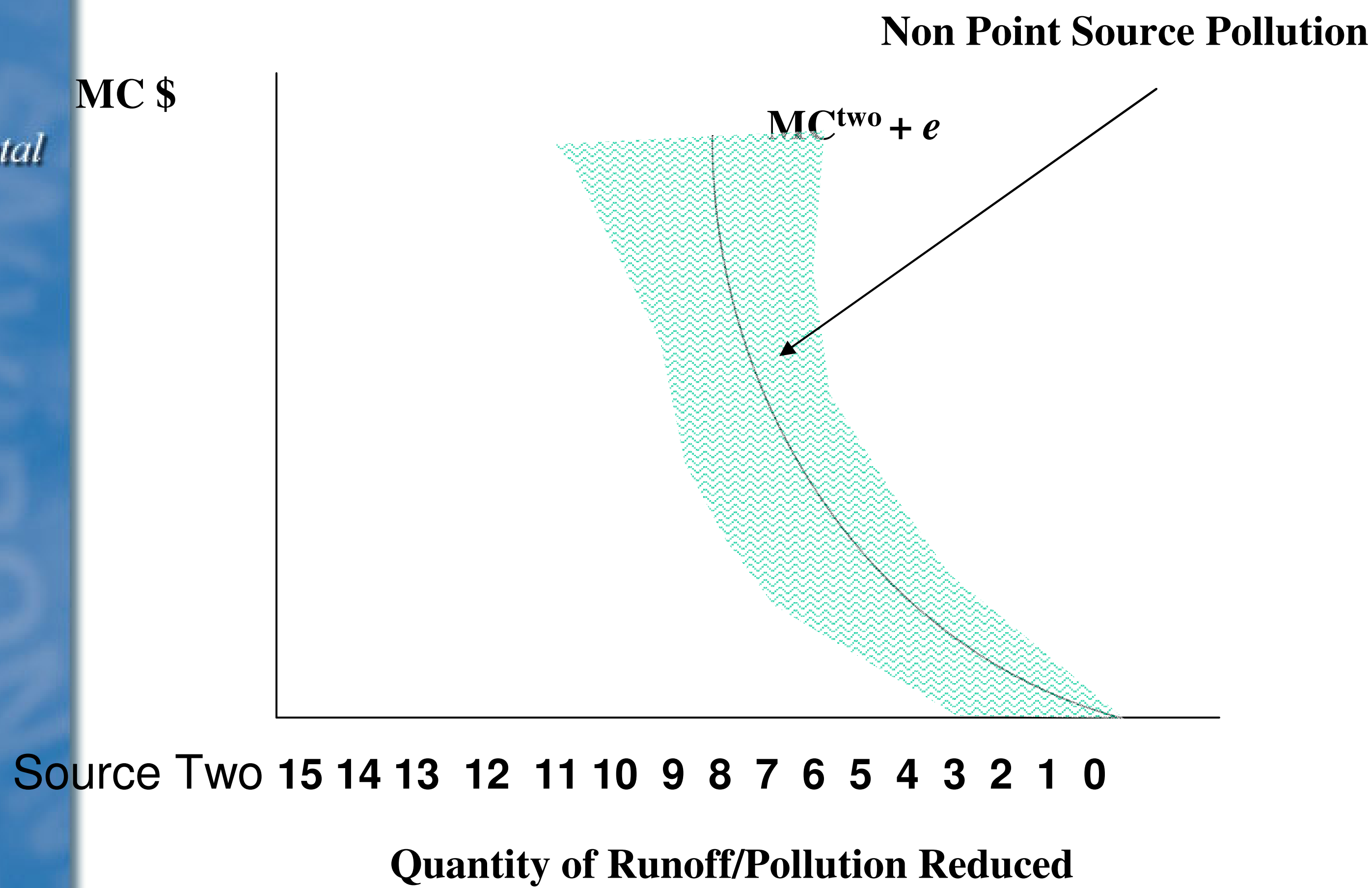

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Issues in Economics

- ***Cost Effectiveness not Guaranteed***
  - Transactions costs
  - Opportunity costs
  - Maintenance costs
  - Non market costs and benefits
  - Unintended costs and benefits
  - Gamesmanship

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Issues in Economics (Cont.)

- **Effectiveness not Guaranteed**
  - Discounting
  - Intergenerational equity
  - Banking
  - Spatial fragmentation
  - Scaling issues
  - Trading ratios

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The Setting

- Agency wants to promote WQT
- Agency wants to see if we can incorporate Wetlands in WQT
- If we do want to, what are some interesting things we should be aware of?

Issues

- Water quality trading has grown in popularity and scope in recent years owing to its potential as a flexible low cost way to achieve water quality goals, especially nutrient removal goals.
- But what's going on? Why stuck at this "awkward pretrading stage of development…" King (2005)

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Issues

- General: thin markets
  - Raffini and Robertson (2005)
  - King and Kuch (2003)
- Demand side King (2005)
  - Political
    - Weak regulation no teeth in cap
- Supply side
  - Political
    - USDA Keynote address
    - Green payments
      - Conservation Reserve Program
      - Wetlands Reserve Program
  - Economic
    - What to do with ancillary benefits
    - Positive Externality

- Increase market size by allowing the inclusion of wetlands
  - The U.S. Department of Agriculture has recently announced that landowners can sell water quality credits from practices that were cost-shared by the National Resources Conservation Service (Knight 2006 [closing remarks at Second Natl WQT conference, Pittsburgh, PA]).
  - Water Assistant Administrator supports inclusion of Wetlands
  - MOU between USDA and US EPA
- And make explicit how ancillary benefits will be treated
  - sequester CO2
  - habitat provision
  - biodiversity protection

- Internalize the externality:
  - 1) including the ancillary benefits of a properly functioning wetland in the market for nutrient removal through subsidies and unique trading ratios, or
  - 2) allowing a producer to trade the various services offered by wetlands in various markets double dip.

- We also examine which option might be preferred depending on the shape of the marginal benefits curve.

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- Wetlands as NPS nutrient removal technology
  - Following Horan and Shortle (2005) include NPS and PS in the trading scheme
    - TC=c(e) + c_r(**x**) + E{D(e, r)}

      c(e) cost to MS4

      c(x) cost to farmer to install, but his damages are cause too by random events

$$(1)\ \frac{\partial TSC}{\partial e} = c^{'}(e) + E\left\{\frac{\partial D}{\partial e}\right\} = 0$$

$$(2)\ \frac{\partial TSC}{\partial x_j} = \frac{\partial c_r(\mathbf{x})}{\partial x_j} + E\left\{\frac{\partial D}{\partial r}\frac{\partial r}{\partial x_j}\right\} = 0, \forall j \neq w$$

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- Add the shadow value of the constraint that initial number of permits is set exogenously

$$L = c(e(q) + c_r(x(p)) + E\big[D(e(q), r(x(p),\theta))\big] + \lambda[(\hat{e}^0 - e(q)) + \left({}^{p}\!/_{q} \right)[\hat{r}^0 - E(r(x(p),\theta))]]$$

- And the "conditionally optimal" trading ratio is

$$t = \frac{E\left[\frac{\partial D}{\partial e}\right] - \lambda\left(\frac{(e - \hat{e}^0)}{e}\right)\varepsilon_{qe} - \lambda\left(\frac{(\hat{r}^0 - E[r])}{E[r]}\right)\varepsilon_{pr}}{E\left[\frac{\partial D}{\partial r}\right] + \left[\frac{\operatorname{cov}\left(\frac{\partial D}{\partial r}, \frac{\partial r}{\partial x_j}\right)}{E\left[\frac{\partial r}{\partial x_j}\right]}\right]}$$

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- Wetlands have ancillary benefits
  - We include a term reflecting the ancillary benefits in the trading scheme
    - TSC=c(e) + c_r(**x**) + E{D(e, r)} - B[xj]

$$(3)\ \frac{\partial TSC}{\partial x_j} = \frac{\partial c_r(\mathbf{x})}{\partial x_j} + E\left\{\frac{\partial D}{\partial r}\frac{\partial r}{\partial x_j}\right\} - B'(x_j) = 0,\ j = w$$

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- Lagrangian with benefits

$$(6)\quad L = c(e(q) + c_r(x(p)) + E\big[D(e(q), r(x(p),\theta))\big] - B[x(p)] + \lambda[(\hat{e}^0 - e(q)) + \left(\frac{p}{q}\right)[\hat{r}^0 - E(r(x(p),\theta))]]$$

- Price of the permit

$$(8)\quad p = E\left[\frac{\partial D}{\partial r}\right] + \frac{\operatorname{cov}\left(\frac{\partial D}{\partial r}, \frac{\partial r}{\partial x_j}\right) - B'[x_j]}{E\left[\frac{\partial r}{\partial x_j}\right]} - \lambda\frac{p}{q} + \lambda\frac{p}{q}\left(\frac{(\hat{r}^0 - E[r])}{E[r]}\right)\varepsilon_{pr}, \forall j = w$$

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Conditionally optimal trading ratio when ancillary benefits are included

$$t = \frac{E\left[\frac{\partial D}{\partial e}\right] - \lambda\left(\frac{(e-\hat{e}^0)}{e}\right)\varepsilon_{qe} - \lambda\left(\frac{(\hat{r}^0 - E[r])}{E[r]}\right)\varepsilon_{pr}}{E\left[\frac{\partial D}{\partial r}\right] + \left[\frac{\operatorname{cov}\left(\frac{\partial D}{\partial r}, \frac{\partial r}{\partial x_j}\right) - B'[x_j]}{E\left[\frac{\partial r}{\partial x_j}\right]}\right]}$$

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This brings up the first interesting thing to be aware of

- With ancillary benefits, the change in price depends on the sign of the covariance term. A negative sign suggests that expected loadings permit price should be higher when ancillary benefits are created. With a positive sign, the change in price depends on whether cov(∂D/∂r, ∂r/∂xj) is greater, less than, or equal to $B'[x_j]$.

- Malik et al. (1993), Shortle (1987), and Horan and Shortle (2005) maintain if the damage function is convex in r, then the covariance term has the same sign as cov(r, E[∂r/∂xj]).

- The sign of this depends on the change in the variance of nonpoint source pollution given a change in the level of abatement. If the level of abatement decreases the variance of nonpoint source pollution, then the covariance is negative.

- While one would think that increasing the level of a specific abatement technology would always reduce the variance of the targeted pollution this is not necessarily the case in such complex systems as wetlands. Bÿstrom et al. (2000) and Mitsch and Gosselink (2000) indicate that wetlands are able to reduce the variance of the nonpoint source pollution. If true, the covariance term is negative and price should be higher when ancillary benefits are generated.
- But evidence from constructed wetlands in Ohio gathered by Spieles and Mitsch (2000) points to a possible increase in variance in a high nutrient riverine system, which means the covariance term is positive.
- Moustafa et al. (1996) find in a wetland in south Florida variance for abatement of Phosphorous decreased but that for Nitrogen did not, further highlighting the complexity of these systems.

- **So** when you have ancillary benefits you have another choice to make
  - Include in the market with ratios/subsidies p
  - Use different markets for different benefits q

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- Woodward and Han (2004) and Montero (2001) tie a Weitzman (1974) price v. quantity argument to the decision to use single or multiple markets based on shape of the marginal benefits curve

Gives us the second interesting thing to be aware of

- Marginal Benefits curves are anything but well understood in this super-complex setting

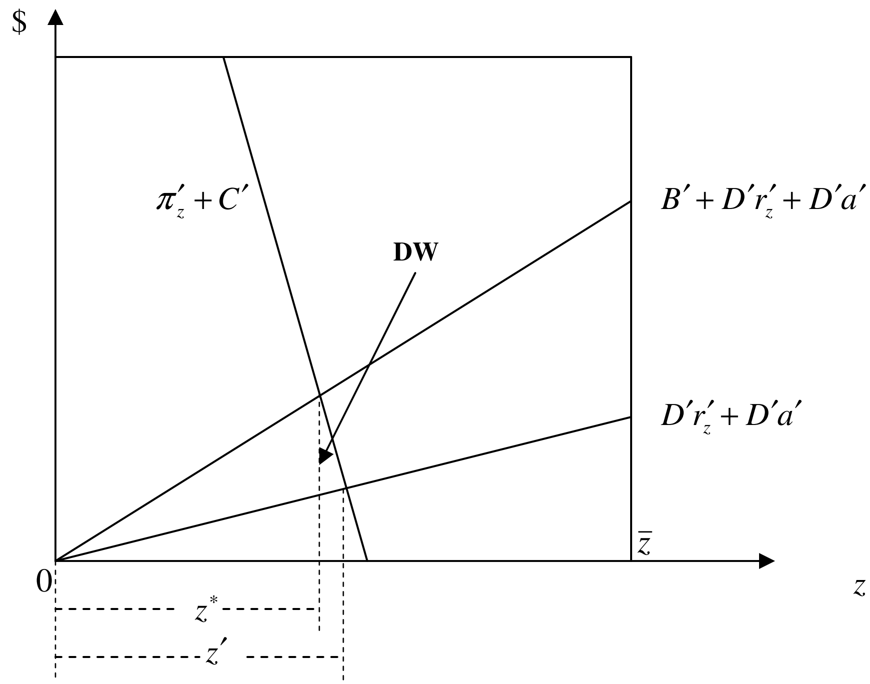

Figure : "Steep" Marginal Benefits of Cropland
e.g.: "Steep" Marginal Costs of Wetland

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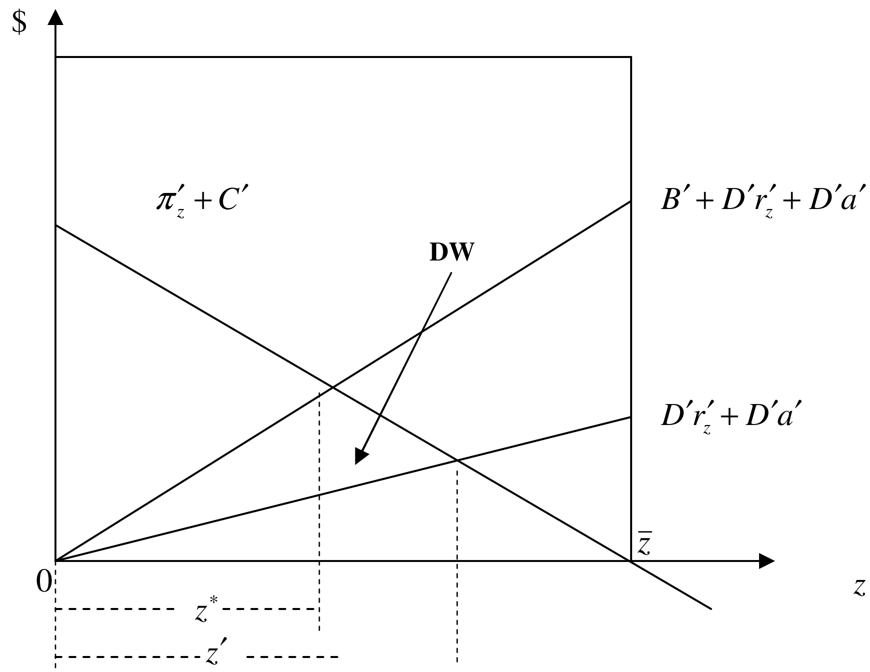

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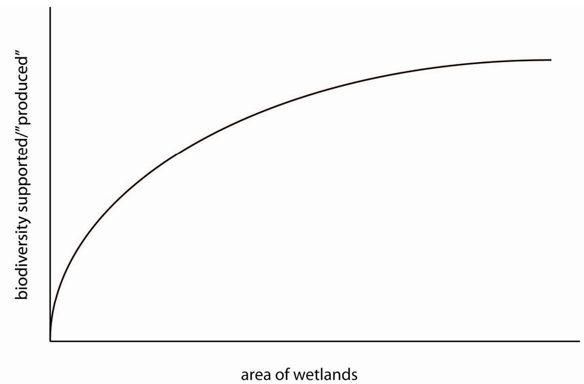

Figure 1. This is based on the classic "species-area curve"; with each additional area unit initially, many new species/functional groups are added which are unique. As more area is added, the number and kinds of new species/functional groups level off.

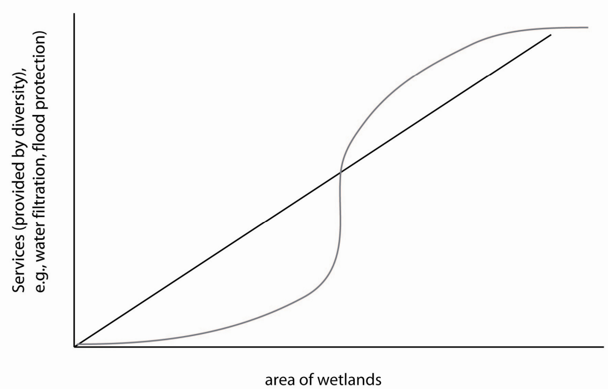

Figure 2. While some of the goods and services may have a relationship similar to Figure 1, I would think some would look like this... for example, if wetlands can filter x number of liters of water per hour, then for each additional wetland it would be a linear relationship to how many more liters could be filtered. Of course, if more diverse wetlands can filter more water than less diverse ones (and given the relationship in Figure 1), I guess this line might even look S-shaped, I don't know.

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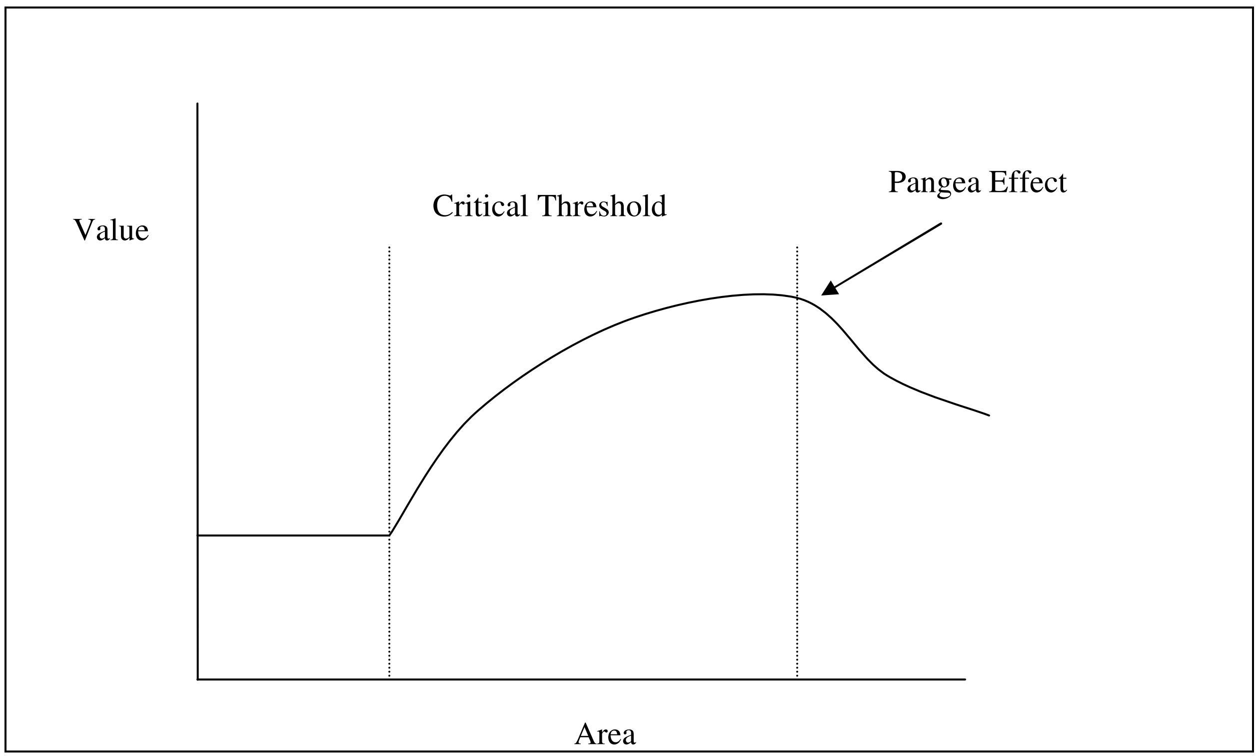

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So our policy hinges on two complex ecological phenomena

- Within ORD there is a nascent large scale research effort to investigate the use of wetlands to reduce nutrient loading in the MRB to address the GHZ
- Measure covariance.
  - Monitor
  - High and low nutrient riverine systems
  - Relationship between N & P
    - P local
    - N global
- Use agglomeration bonus or other policy tools to reduce uncertainty about benefits function

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Research Directions

- National Wetlands Newsletter article (forthcoming Jan/Feb 2007)
- MM&I Progress Review presentation (Oct. 18, 2006)
- Manuscript on economic theory and ecological considerations
- EPA report, literature review (SHAW contract)
- Experimental Economics Research?
- Case Study?